

Table 3. Seasonal prevalence, mean abundance, and mean intensity of *Parapharyngodon garciae* infection in *Eleutherodactylus johnstonei* in Bermuda, 1995.

Study site	March			July			November		
	Prevalence (%) <sup>a</sup>	Mean Abundance ( $\bar{x} \pm$ SD)	Mean intensity (range)	Prevalence (%) <sup>a</sup>	Mean Abundance ( $\bar{x} \pm$ SD)	Mean intensity (range)	Prevalence (%) <sup>a</sup>	Mean Abundance ( $\bar{x} \pm$ SD)	Mean intensity (range)
Ft. Albert									
BBSR	42 (5/12)	0.5 $\pm$ 0.7	1.2 (1–2)	0 (0/10)	0.6 $\pm$ 0.9	1.7 (1–3)	0 (0/10)	2.7 $\pm$ 1.6	2.7 (1–5)
St. David's				33 (6/18)	0.6 $\pm$ 0.8	1.4 (1–2)	50 (10/20)	0.3 $\pm$ 0.6	1.3 (1–2)
Perfurnery				42 (8/19)	0.4 $\pm$ 0.6	1.2 (1–2)	24 (4/17)	0.2 $\pm$ 0.4	1.0 (1–1)
Harrington Sound	42 (17/41)	0.6 $\pm$ 0.9	1.5 (1–4)	33 (6/18)	0.1 $\pm$ 0.4	1.0 (1–1)	20 (4/20)	0.8 $\pm$ 1.0	1.7 (1–4)
Turks Head				14 (2/14)	0.3 $\pm$ 0.6	0.7 (1–2)	45 (9/20)		
Bermuda Florist				20 (4/20)					
Pagel Marsh							20 (4/20)	0.3 $\pm$ 0.5	1.3 (1–2)
Barton's				5 (1/20)	0.1 $\pm$ 0.4	2.0	10 (1/10)	0.1 $\pm$ 0.3	1.0
Cameron							13 (2/16)	0.1 $\pm$ 0.3	2.0 (1–1)
Sea Swept				20 (1/5)	0.2 $\pm$ 0.4	1.0	35 (7/20)	0.6 $\pm$ 0.9	1.7 (1–3)
Lukes Pond				10 (1/10)	0.2 $\pm$ 0.6	2.0	59 (10/17)	1.1 $\pm$ 1.1	1.8 (1–3)
Soundview				0 (0/21)			55 (11/20)	0.9 $\pm$ 0.9	1.7 (1–2)
							0 (0/19)		

<sup>a</sup> Numbers in parentheses are no. frogs infected/no. frogs examined.

= 8.9, 1 df,  $P < 0.01$ ), whereas differences between March and July ( $\chi^2 = 2.5$ ) and July and November ( $\chi^2 = 0.66$ ) were not significant. The difference in infection rate between July and November at the Soundview site was highly significant ( $\chi^2 = 17.43$ , 1 df,  $P < 0.0005$ ).

Cysts containing larvae of *Abbreviata* sp. were present on the walls of the stomach, small intestine, large intestine, and urinary bladder in March: 34 of 53 frogs (64%), 10/16 (63%) males, 24/37 (65%) females; July: 107 of 155 frogs (69%), 66/99 (67%) males, 41/56 (73%) females; and November: 161 of 219 frogs (73%), 66/89 (74%) males, 95/131 (73%) females. A highly significant difference in the seasonal infection rate (March, July, and November) was recorded at the BBSR ( $\chi^2 = 20.029$ , 2 df,  $P < 0.01$ ) but not at the Harrington Sound site ( $\chi^2 = 3.415$ , 2 df,  $P > 0.05$ ). The differences between July and November infection rates were not significant at Sea Swept ( $\chi^2 = 2.43$ ), Soundview ( $\chi^2 = 3.10$ ), Lukes Pond ( $\chi^2 = 3.61$ ), or St. David's ( $\chi^2 = 2.68$ ).

*Parapharyngodon garciae* was found in the small and large intestines in March: 22 of 53 frogs (43%), 6/16 (38%) males, 16/37 (43%) females; July: 29 of 155 frogs (19%), 20/99 (20%) males, 9/56 (16%) females; and November: 62 of 219 frogs (28%), 29/88 (33%) males, 33/131 (25%) females. Differences in infection rates were not significant at any site except Lukes Pond, where the difference between July and November infection rates was highly significant ( $\chi^2 = 5.63$ , 1 df,  $P < 0.01$ ).

One immature male oxyurid nematode was found in the small intestine of a female frog from Fort Albert in St. George's Parish. It was identified as *Batracholandros* sp. by Jean-Pierre Hugot, who noted that because pinworms are rare in anurans and none have ever been described from Bermuda, this specimen probably represents an undescribed species. The poor condition of the specimen, however, made further identification impossible.

One specimen of the trematode *Mesocoelium monas* was taken from the stomach of a female from Paget Cemetery in Paget Parish in July 1995 (prevalence = 5% [1/20]; abundance =  $0.05 \pm 0.22$  [SD]; mean intensity = 1.0). During July, 34 opacoelid trematodes were identified in the liver, gall bladder, and bile ducts of a female frog from Harrington Sound in Smith's Parish (prevalence = 7% [1/14]; abundance  $0.29 \pm$

1.03; mean intensity = 4.0) and a female frog from Paget Cemetery (prevalence = 5% [1/20]; abundance =  $1.5 \pm 6.54$ ; mean intensity = 30.0). During November, a total of 48 trematodes were identified in 1 female frog from St. David's Island in St. George's Parish (prevalence = 6% [1/17], abundance =  $0.18 \pm 0.71$ , mean intensity = 3.0), 1 male frog from Fort Albert in St. George's Parish (prevalence = 5% [1/20], abundance =  $0.5 \pm 2.17$ , mean intensity = 10.0), 2 males from Soundview Drive in Sandy's Parish (prevalence = 11% [2/19], abundance =  $0.89 \pm 3.56$ , mean intensity = 8.5, range = 1–16), and 4 females from D. Barton's in Paget Parish (prevalence = 25% [4/16], abundance =  $1.13 \pm 2.02$ , mean intensity = 4.5, range = 3–6).

There are 3 previous reports on helminths of amphibians from Bermuda. Williams (1959) reported *Cosmocerca* sp., *Aplectana* sp., and *Thelandros* sp. Goldberg et al. (1995) reported *Aplectana* sp., *Parapharyngodon garciae*, and larval physalopterans. Burnie (1989) found metacercariae of the feline liver fluke, *Platynosomum concinnum*, in *Eleutherodactylus* spp.

Goldberg et al. (1995) found *Aplectana* sp. in 18 of 84 (21%) *E. johnstonei* and *Parapharyngodon garciae* in 25 of 84 (30%) of these frogs on the grounds of the BBSR. Williams (1959) reported 18 of 26 *E. johnstonei* to be infected by nematodes of the genera *Cosmocerca*, *Aplectana*, or *Thelandros*; specific rates of infection were not given. In this study, 136 of 427 (32%) *E. johnstonei* harbored *Aplectana* sp. and 102 of 427 (24%) of these frogs harbored *P. garciae*. There is no significant difference between the results of Goldberg et al. (1995) and those of this study for *P. garciae* ( $\chi^2 = 1.32$ , 1 df,  $P > 0.05$ ); however, there is a significant difference between the studies concerning *Aplectana* sp. ( $\chi^2 = 3.87$ , 1 df,  $P < 0.05$ ).

The *Batracholandros* sp. and the opacoelid trematodes represent new records of parasitism in *E. johnstonei* and in Bermuda. The single immature male oxyurid found in the small intestine of a female *E. johnstonei* may represent the ingestion of a nematode normally found within insect prey of the frog. The opacoelids were found in the liver, gall bladder, and bile ducts of 10 frogs, with 30 of the 82 trematodes found in a single female frog. The trematode intestinal ceca were fused to form a uroproct, and an accessory sucker and papillae were present around the ven-

tral sucker. No ova were present. Species of opeoelids encyst in amphipods (Schell, 1985); amphipods were identified as food items at each site except Paget Cemetery and Harrington Sound.

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## Research Note

# Seasonal Occurrence of Helminths of the Giant Toad, *Bufo marinus* (Amphibia: Bufonidae), in Bermuda

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**ABSTRACT:** One hundred sixty-seven giant toads, *Bufo marinus*, from 7 study sites in Bermuda were examined for helminths during March, July, and November 1995, August 1996, and May 1997. Three nematode species, *Rhabdias fuelleborni*, *Aplectana* sp., and *Abbreviata* sp., and 2 trematode species, *Mesocoelium monas* and *Clinostomum* sp., were found. Prevalence for *Rhabdias fuelleborni* was 25–100%, for *Aplectana* sp. was 0–67%, for *Abbreviata* sp. was 20–100%, and for *Mesocoelium monas* was 0–100%.

**KEY WORDS:** *Bufo marinus* (Bufonidae), Nematoda, *Rhabdias fuelleborni*, *Aplectana* sp., *Abbreviata* sp., Trematoda, *Mesocoelium monas*, *Clinostomum* sp.

Natural populations of the giant toad, *Bufo marinus* (Linnaeus, 1758), occur continuously from extreme southern Texas and northwestern Mexico to central Brazil (Easteal, 1986). The species has, however, been widely introduced in Bermuda, the Caribbean (Jamaica, Puerto Rico, U.S. Virgin Islands, Hispaniola, Barbados, Grenada, St. Vincent, St. Lucia, Martinique, Guadeloupe, St. Christopher, Nevis, Montserrat, Antigua) (Schwartz and Henderson, 1991), and the Pacific (Australia, New Guinea, Fiji, the Philippines) (Easteal, 1981). In Bermuda, approximately 24 individuals from Guyana were released in a garden in Devonshire Parish about

# The Bermuda Islands

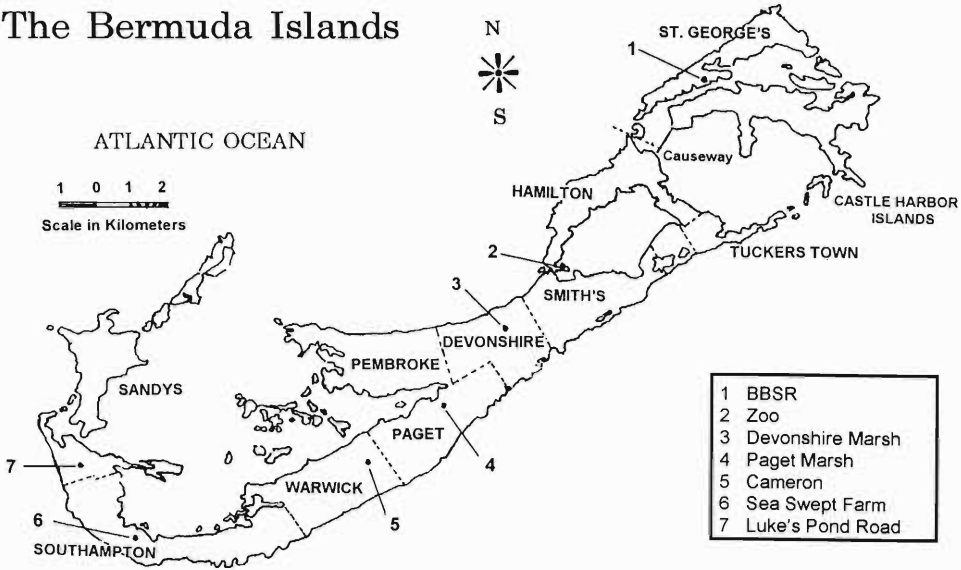


Figure 1. Study sites for *Bufo marinus* in Bermuda.

1885 by Captain Nathaniel Vesey (Wingate, 1965). For the next 100 yr, the toad population flourished and became extremely abundant. About 1990, a significant decline in numbers was noticed (Dow, 1993). In March 1995, a long-term study was begun to gather baseline data and to determine the cause(s) for this decline. The purpose of this study was to identify parasites harbored by *Bufo marinus*, to compare seasonal parasite loads among various populations on the islands, and to compare annual changes over time.

Thirty-one *B. marinus* (29 males, 2 females) were collected from 2 sites during 21–24 March 1995: 26 (25 males, 1 female) were taken on the grounds of the Bermuda Biological Station for Research (BBSR) in St. George's Parish and 5 (4 males, 1 female) were taken at Devonshire Marsh in Devonshire Parish. Mean ( $\pm$ SE) snout–vent length (SVL) =  $130.5 \pm 9.2$  mm, range = 107–147 mm. Mean ( $\pm$ SE) weight =  $209.5 \pm 45.8$  g, range = 100–290 g. Forty-nine toads (39 males, 10 females) were obtained during 11–22 July 1995 from 6 sites: BBSR (11), Devonshire Marsh (10), Flatts in Hamilton Parish (13), Paget Marsh in Paget Parish (10), Cam-

eron in Warwick Parish (2), and Sea Swept Farm in Southampton Parish (3). The SVL =  $115.9 \pm 18.0$  mm, range = 77–158 mm. Weight was  $156.7 \pm 75.0$  g, range = 34.9–383.1 g. Thirty-four toads (16 males, 18 females) were taken from sites during 21–23 November 1995: BBSR (8), Devonshire Marsh (3), Flatts (4), Paget Marsh (2), Sea Swept Farm (10), and Lukes Pond Road in Southampton Parish (7). The SVL =  $114.1 \pm 15.0$  mm, range = 82–160 mm. Weight was  $144.5 \pm 68.2$  g, range = 50.7–357.4 g. Twenty toads (13 males, 7 females) were taken from the BBSR during 8–9 August 1996. The SVL =  $111.5 \pm 9.8$  mm, range = 93.0–124.0 mm. Weight was  $136.6 \pm 43.3$  g, range = 62.0–229.0 g. Thirty-three toads (15 males, 18 females) were taken from 5 sites on 20 May 1997: BBSR (10), Devonshire Marsh (6), Flatts (6), Paget Cemetery (5), and Sea Swept Farm (6). The SVL =  $121.4 \pm 2.31$  mm, range = 94.0–150.0 mm. Weight was  $171.3 \pm 10.60$  g, range = 54.7–345.6 g.

Study sites are shown in Figure 1. Approximate straight-line distances from the BBSR are Flatts, 6 km SW; Devonshire Marsh, 8 km SW; Paget Marsh, 11 km SW; Cameron, 13 km SW;

Sea Swept Farm, 18.5 km SW; and Lukes Pond Road, 20 km SW.

All specimens were frozen immediately upon return to the BBSR. Later, each individual was thawed, measured, and weighed. The lungs, liver, gall bladder and bile duct, stomach, small intestine, large intestine, and urinary bladder were removed and examined separately using dissecting and compound microscopes. Nematodes were identified using the standard glycerol wet-mount procedure. Trematodes were stained with Ehrlich's hematoxylin and mounted in Canada balsam. Terminology follows that of Bush et al. (1997). Selected helminths were deposited in the U.S. National Parasite Collection (USDA, Beltsville, Maryland): *Rhabdias fuelleborni*, 87195; *Abbreviata* sp., 87196; *Aplectana* sp., 87197; and *Mesocoelium monas*, 87198.

Seasonal prevalence, mean abundance, and mean intensity for each helminth are given in Tables 1–4. For March, 29 of 31 (94%) *B. marinus* harbored helminths; for May, 10 of 10 (100%); for July and August, 69 of 69 (100%); and for November, 29 of 34 (85%).

*Rhabdias fuelleborni* Travassos, 1926, was found only in the lungs in March: 27 of 31 toads (87%), 25/29 males (86%), 2/2 females (100%); May: 19 of 33 toads (58%), 15/18 males (83%), 4/15 females (27%); July–August: 52 of 69 toads (76%), 39/51 males (76%), 13/18 females (72%); and November: 20 of 34 toads (59%), 10/16 males (63%), 10/18 females (56%).

*Aplectana* sp. (females only) were found in the large intestines in March: 4 of 31 toads (13%), 2/29 males (7%), 2/2 females (100%); May: 0 of 33 toads; July–August: 3 of 69 toads (4%), 2/51 males (4%), 1/18 females (6%); and November: 1 of 34 toads (3%), 1/16 males (6%).

Cysts containing larvae of *Abbreviata* sp. were found in the walls of the stomach and urinary bladder in March: 20 of 31 toads (65%), 19/29 males (66%), 1/2 females (50%); May: 27 of 33 toads (82%), 14/18 males (78%), 13/15 females (87%); July–August: 34 of 69 toads (49%), 26/52 males (50%), 8/17 females (47%); and November: 20 of 34 toads (59%), 11/16 males (69%), 9/18 females (50%).

The trematode *M. monas* (Rudolphi, 1819) Freitas, 1958, was found in the duodenum and jejunum of 16 of 31 toads (52%) in March, 15/29 males (52%), 1/2 females (50%); 23 of 33 toads (70%) in May, 11/18 males (61%), 12/15 females (80%); 50 of 69 toads (72%) in July and

August, 40/52 males (77%), 10/17 females (59%); and in 16 of 34 toads (47%) in November, 8/16 males (50%), 8/18 females (44%).

Two trematodes identified as *Clinostomum* sp. metacercariae were found in the small intestine of a male *B. marinus* from Paget Parish.

There are 3 published reports on helminths of *B. marinus* from Bermuda. Williams (1959, 1960) reported *Rhabdias sphaerocephala* and *Aplectana vellardi*, and Goldberg et al. (1995) reported *Aplectana* sp., *R. fuelleborni*, and *Mesocoelium monas*. One unpublished 1992 student report from the Bermuda Biological Station library reported *R. bufonis* and a "pinworm" (Lightbourne, unpubl.).

Goldberg et al. (1995) examined 45 adult *B. marinus* collected on the grounds of the BBSR 14–18 August 1992 and reported *R. fuelleborni* in 32 (71%) toads. Williams (1959, 1960) reported *R. sphaerocephala* from 33 of 40 toads (83%) taken between 9 June and 21 July 1957 from the parishes of St. George's, Smith's, Pembroke, and Devonshire. The unpublished student project reported *R. bufonis* in 1 of 5 toads (20%) taken in Pembroke Parish. Baker (1987) considered both *R. bufonis* and *R. sphaerocephala* to be European species and stated that American records of *R. sphaerocephala* need to be confirmed. Specimens of *Rhabdias* from Bermuda lack the anterior body wall swelling and cuticular inflation and the anterior esophageal swelling of *R. sphaerocephala*, and they are somewhat shorter in total length. They best fit the description of *R. fuelleborni* as given by Travassos (1926). No significant differences were found when the combined infection rates from 3 collecting periods in this study (March, July–August, and November) were compared with those of the summer sample of Williams (1959) ( $\chi^2 = 0.84$ , 1 df,  $P > 0.05$ ) and the August sample of Goldberg et al. (1995) ( $\chi^2 = 0.92$ , 1 df,  $P > 0.05$ ).

Goldberg et al. (1995) also reported 39 of the 45 toads (87%) harboring *Aplectana* sp. Because only females of this worm were found, identification to species was not attempted. Williams (1959) reported 10 of 40 toads (25%) harboring *Aplectana vellardi*. In the present study, 8 of 134 toads (6%) were infected by *Aplectana* sp. Identification to species was not attempted because of the lack of male specimens. When the combined prevalences from 3 collecting periods from this study (March, July–August, and No-

Table 1. Seasonal prevalence, mean abundance, and mean intensity of *Rhabdias fuelleborni* infection in *Bufo marinus* in Bermuda.

	BBSR			Flatts	Devonshire Marsh	Paget Marsh	Cameron	Sea Swept	Lukes Pond
	1995	1996	1997						
March 1995 ( <i>n</i> = 31)									
Prevalence (%)*	85 (22/26)				100 (5/5)				
Mean Abundance ( $\pm$ SD)	12.5 $\pm$ 12.5				4.4 $\pm$ 4.3				
Mean intensity	14.8				4.4				
(range)	(1-44)				(1-8)				
May 1997 ( <i>n</i> = 33)									
Prevalence (%)*			80 (8/10)	67 (4/6)	67 (4/6)	60 (3/5)		0/6	
Mean Abundance ( $\pm$ SD)			21.2 $\pm$ 21.5	13.8 $\pm$ 15.8	8.8 $\pm$ 11.6	8.8 $\pm$ 12.2			
Mean intensity			26.5	20.8	13.3	14.7			
(range)			(2-61)	(6-37)	(1-28)	(2-32)			
July-August 1995-1996 ( <i>n</i> = 69)									
Prevalence (%)*	64 (7/11)	60 (12/20)		85 (11/13)	70 (7/10)	80 (8/10)	100 (2/2)	67 (2/3)	
Mean Abundance ( $\pm$ SD)	12.4 $\pm$ 20.9	6.3 $\pm$ 10.6		28.0 $\pm$ 32.7	5.5 $\pm$ 5.8	27.1 $\pm$ 23.9	7.0 $\pm$ 6.0	3.0 $\pm$ 1.7	
Mean intensity	19.4	10.6		33.1	7.9	33.9	7.0	4.5	
(range)	(1-76)	(1-21)		(3-114)	(1-16)	(3-53)	(1-8)	(1-8)	
November 1995 ( <i>n</i> = 34)									
Prevalence (%)*	88 (7/8)			25 (1/4)	100 (3/3)	50 (1/2)		40 (4/10)	57 (4/7)
Mean Abundance ( $\pm$ SD)	3.0 $\pm$ 2.6			6.0 $\pm$ 10.4	21.3 $\pm$ 14.8	3.5 $\pm$ 3.5		5.4 $\pm$ 13.2	9.7 $\pm$ 17.3
Mean intensity	3.4			24.0	21.3	7.0		13.5	17.0
(range)	(1-8)				(8-42)			(1-45)	(1-50)

\* Numbers in parentheses are no. toads infected/no. toads examined.

Table 2. Seasonal prevalence, mean abundance, and mean intensity of *Aplectana* sp. infection in *Bufo marinus* in Bermuda.

	BBSR			Devonshire		Cameron	Sea Swept	Lukes Pond
	1995	1996	1997	Flats	Marsh			
March 1995 ( <i>n</i> = 31)								
Prevalence (%)*	4 (1/26)				60 (3/5)			
Mean Abundance ( $\pm$ SD)	0.04 $\pm$ 0.2				5.8 $\pm$ 8.22			
Mean intensity	1.0				9.7			
(range)					(2–13)			
May 1997 ( <i>n</i> = 33)								
Prevalence (%)*			0/10	0/6	0/6	0/5	0/6	
July–August 1995–1996 ( <i>n</i> = 69)								
Prevalence (%)*	0/11	0/20		0/13	0/10	20 (2/10)	50 (1/2)	67 (2/3)
Mean Abundance ( $\pm$ SD)						17.8 $\pm$ 52.1	21.0 $\pm$ 21.0	3.0 $\pm$ 1.7
Mean intensity						89.0	42.0	4.5
(range)						(4–174)		(1–8)
November 1995 ( <i>n</i> = 34)								
Prevalence (%)*	0/8			0/4	33 (1/3)	0/2	0/10	0/7
Mean Abundance ( $\pm$ SD)					0.3 $\pm$ 0.5			
Mean intensity					1.0			
(range)								

\* No. toads infected/no. toads examined.

Table 3. Seasonal prevalence, mean abundance, and mean intensity of *Abbreviata* sp. infection in *Bufo marinus* in Bermuda.

	BBSR			Flatts	Devonshire		Paget Marsh	Cameron	Sea Swept	Lukes Pond
	1995	1996	1997		Marsh					
March 1995 ( <i>n</i> = 31)										
Prevalence (%)*	62 (16/26)				80 (4/5)					
Mean Abundance (±SD)	5.5 ± 10.8				22.0 ± 16.0					
Mean intensity	11.4				27.5					
(range)	(1–46)				(20–50)					
May 1997 ( <i>n</i> = 33)										
Prevalence (%)*			70 (7/10)	100 (6/6)	100 (6/6)	40 (2/5)		100 (6/6)		
Mean Abundance (±SD)			28.2 ± 39.4	40.2 ± 29.0	23.3 ± 20.3	12.2 ± 23.9		30.5 ± 20.2		
Mean intensity			40.3	40.2	23.3	30.5		30.5		
(range)			(1–121)	(10–83)	(4–58)	(1–60)		(4–64)		
July–August 1995–1996 ( <i>n</i> = 69)										
Prevalence (%)*	55 (6/11)	3.5 (7/20)		54 (7/13)	20 (2/10)	80 (8/10)	100 (2/2)	67 (2/3)		
Mean Abundance (±SD)	10.0 ± 10.4	7.8 ± 15.4		4.5 ± 10.4	2.4 ± 6.0	19.1 ± 17.5	20.0 ± 0.0	13.3 ± 9.4		
Mean intensity	18.3	22.1		8.3	12.0	23.9	20.0	20.0		
(range)	(10–30)	(1–60)		(1–40)	(4–20)	(1–50)	(20–20)	(20–20)		
November 1995 ( <i>n</i> = 34)										
Prevalence (%)*	88 (7/8)			100 (4/4)	33 (1/3)	50 (1/2)		30 (3/10)	57 (4/7)	
Mean Abundance (±SD)	21.3 ± 13.6			102 ± 98.0	1.7 ± 2.4	2.5 ± 2.5		6.0 ± 9.2	11.4 ± 11.0	
Mean intensity	24.3			102.0	5.0	5.0		20.0	20.0	
(range)	(10–50)			(3–200)				(20–20)	(10–25)	

\* Numbers in parentheses are no. toads infected/no. toads examined.